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(54) [Title of the Invention] Subcarrier for mounting semiconductor laser element and semiconductor laser module

(57) [Summary]
[Problems] Temperature control cannot be performed quickly and highly accurately with respect to a semiconductor laser element. In addition, a subcarrier and a module each undesirably have a large size.
[Solving Means] There are provided a subcarrier for mounting a semiconductor laser element including a mount part 8 for mounting a semiconductor laser element 4 and a temperature measuring element 5 formed so as to surround the mount part 8 that are provided on a substrate 7, and a semiconductor laser module including the same. The distance between the semiconductor laser element 4 and the temperature measuring element 5 becomes short and the temperature measuring element 5 can receive the heat of the semiconductor laser element 4 substantially uniformly from the directions corresponding to the entire periphery of the semiconductor laser element 4, so that temperature control can be performed quickly and highly accurately. In addition, the temperature measuring element 5 occupies a small area. This allows a subcarrier 1 to be miniaturized and the module also to be miniaturized accordingly.

[Scope of Claims]

[Claim 1]

A subcarrier for mounting a semiconductor laser element, comprising:

a substrate;

a mount part for mounting a semiconductor laser element; and

a temperature measuring element formed to surround the mount part,

wherein the mount part and the temperature measuring element are provided on the substrate.

[Claim 2]

A semiconductor laser module, comprising:

a package composed of a base member and a cover;

a Peltier element mounted on the base member;

a subcarrier for mounting a semiconductor laser element according to claim 1 that is mounted on the Peltier element; and

a semiconductor laser element mounted on the subcarrier,

wherein the Peltier element, the subcarrier, and the semiconductor laser element are contained hermetically inside the package.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention belongs]

The present invention relates to a subcarrier for mounting a semiconductor laser element and to a semiconductor laser module for optical communication that includes the same.

[0002]

[Prior Art]

In a semiconductor laser element used in a semiconductor laser module for optical communication, its emission wavelength, optical output, and the like vary with its temperature.

[0003]

Hence, in order to operate the semiconductor laser element stably, it is necessary to control the temperature of the semiconductor laser element to a predetermined temperature.

[0004]

Conventionally, such control of the temperature of the semiconductor laser element is performed with a temperature measuring element for measuring the temperature of the semiconductor laser element and a Peltier element for cooling or heating the semiconductor laser element based on the information as to the temperature of the semiconductor laser element measured by the temperature measuring element.

[0005]

Such temperature measuring element and Peltier element are contained together with the semiconductor laser element in a package that can be sealed hermetically to compose a semiconductor laser module.

[0006]

Here, FIG. 3 shows a cross-sectional view of an example of a conventional semiconductor laser module.

[0007]

The conventional semiconductor laser module includes a Peltier element 23, a semiconductor laser element 24, and a temperature measuring element 25 that are contained hermetically inside a package composed of a base member 21 and a cover 22. Note that the semiconductor laser element 24 and the temperature measuring element 25 are disposed on a subcarrier 26 for mounting them.

[0008]

The base member 21 of the package is made of, for example, ceramics such as an aluminum oxide sintered compact or a metal such as a copper-tungsten alloy, an iron-nickel-cobalt alloy, or the like. The base member 21 is mainly composed of a flat base plate part 21a and a frame-like sidewall part 21b.

[0009]

The Peltier element 23 is mounted on and fixed to the upper face of the base plate part 21a of the base member 21. Above the upper face of the Peltier element 23 are mounted the semiconductor laser element 24 and the temperature measuring element 25 that are disposed on the subcarrier 26 for mounting a semiconductor laser element.

[0010]

A pipe 27 made of a metal such as an iron-nickel alloy, an iron-cobalt-nickel alloy, or the like is attached to the sidewall part 21b of the base member 21. An optical fiber 28 is passed through the interior of the pipe 27.

[0011]

The optical fiber 28 is disposed such that its end faces the semiconductor laser element 24 and thereby light emitted from the semiconductor laser element 24 can be transmitted to the outside through the optical fiber 28.

[0012]

Furthermore, lead terminals 29 are fixed to the base plate part 21a or the sidewall part 21b of the base member 21. To the lead terminals 29 are electrically connected the Peltier element 23, the semiconductor laser element 24, and the temperature measuring element 25.

[0013]

The cover 22 is a flat plate made of a metal such as an iron-nickel-cobalt alloy, an iron-nickel alloy, or the like and is joined to the upper face of the sidewall part 21b of the base member 21 by, for example, seam welding. Thus, the package composed of the base member 21 and the cover 22 containing the Peltier element 23, the semiconductor laser element 24, and the temperature measuring element 25 thereinside is sealed hermetically.

[0014]

The subcarrier 26 for mounting a semiconductor laser element that is used in this conventional semiconductor laser module is described further in detail with respect to FIG. 4.

[0015]

FIG. 4 is a perspective view showing the subcarrier 26, and the semiconductor laser element 24 and the temperature measuring element 25 that are disposed thereon shown in FIG. 3.

[0016]

The subcarrier 26 includes a mount part 31 formed of a metal thin film for mounting the semiconductor laser element 24 on one end side of the upper face of a substrate 30 made of an electrical insulating material such as an aluminum oxide sintered compact or the like, for example. The metal thin film forming the mount part 31 is a metal thin film having a three-layer structure including, for example, a titanium film, a platinum film, and a gold film sequentially. The semiconductor laser element 24 is fixed to the mount part 31 formed of this metal thin film with a brazing filler metal made of, for example, a gold-tin alloy. The subcarrier 26 also is provided with a metal thin film (not shown in the figure) having a three-layer structure including, for example, a titanium film, a platinum film, and a gold film sequentially, which adheres to its substantially whole rear face. This metal thin film on the rear face and the Peltier element 23 are brazed, so that the subcarrier 26 is fixed onto the Peltier element 23.

[0017]

On the other hand, the temperature measuring element 25 is formed of a thin film of a resistance material such as molybdenum silicide nitride or the like. The temperature measuring element 25 is bent in a zigzag pattern and is provided on the other end side of the upper face of the substrate 30. In the temperature measuring element 25, its electrical resistivity varies with temperature. The change in the electrical resistivity of the temperature measuring element 25 is transmitted to an external control circuit through the lead terminals 29. The Peltier element 23 is operated according to the instruction from the control circuit and thereby the semiconductor laser element 24 is controlled to have a predetermined temperature.

[0018]

[Problems to be solved by the Invention]

In this conventional semiconductor laser module, however, since the temperature measuring element 25, which is bent in a zigzag pattern, is provided on the one end side of the upper face of the subcarrier 26, the distance between the temperature measuring element 25 and the semiconductor laser element 24 becomes long. This results in poor followingness in changing the resistivity of the temperature measuring element 25 with respect to the change in temperature of the semiconductor laser element 24. In addition, since the temperature measuring element 25 bent in the zigzag pattern receives the heat from the semiconductor laser element from only one direction, the heat tends to be transmitted non-uniformly to the temperature measuring element 25 uniformly

and thereby it is difficult to carry out temperature control quickly and highly accurately, which has been a problem. In addition, since the pattern of the temperature measuring element 25 bent in a zigzag manner occupies a large area on the subcarrier 26, the size of the subcarrier 26 is increased. As a result, the sizes of the Peltier element on which the subcarrier 26 is mounted and the package also are increased, which also has been a problem.

[0019]

The present invention has been made with such conventional problems in mind and an object of the present invention is to provide a subcarrier for mounting a semiconductor laser element and a semiconductor laser module that can perform temperature control quickly and highly accurately by shortening the distance from a semiconductor laser element to a temperature measuring element and making the heat transmission from the semiconductor laser element to the temperature measuring element substantially uniform.

[0020]

In addition, another object of the present invention is to provide a small subcarrier for mounting a semiconductor laser element on which a temperature measuring element does not occupy a large area, and a small semiconductor laser module including the same.

[0021]

[Means for solving the Problem]

In addition, the subcarrier for mounting a semiconductor laser element of the present invention is characterized by including a mount part for mounting a semiconductor laser element and a temperature measuring element formed so as to surround the mount part that are provided on a substrate.

[0022]

The semiconductor laser module of the present invention is characterized by including a Peltier element mounted on a package composed of a base member and a cover, a subcarrier for mounting a semiconductor laser element with the above-mentioned configuration that is mounted on the Peltier element, and a semiconductor laser element mounted on the subcarrier all of which are contained hermetically inside the package.

[0023]

According to the subcarrier for mounting a semiconductor laser of the present invention, the temperature measuring element is disposed so as to surround the mount part on which the semiconductor laser element is to be mounted. Hence, the distance from the temperature measuring element to the semiconductor laser element is allowed to be shortened and the temperature measuring element can substantially uniformly

receive the heat of the semiconductor laser element by its periphery. At the same time, the temperature measuring element does not occupy a large area on the subcarrier.

[0024]

In addition, according to the semiconductor laser module of the present invention including the above-mentioned subcarrier, the temperature of the semiconductor laser element is measured accurately with high followingness by the temperature measuring element provided on the subcarrier, and based on the temperature information thus obtained, the Peltier element can be operated quickly and highly accurately. Furthermore, the small subcarrier is contained and accordingly the Peltier element on which the subcarrier is mounted and the package also are not required to have large sizes. Hence, the module can be miniaturized.

[0025]

[Embodiment Mode of the Invention]

Next, the present invention is described in detail with reference to the attached drawings.

[0026]

FIG. 1 is a cross-sectional view showing an example of an embodiment of a subcarrier for mounting a semiconductor laser and a semiconductor laser module including the same according to the present invention. In the semiconductor laser module of the present invention, a Peltier element 3, a semiconductor laser element 4, and a temperature measuring element 5 are contained hermetically inside a package composed of a base member 1 and a cover 2. Note that the semiconductor laser element 4 and the temperature measuring element 5 are disposed on a subcarrier 6 for mounting a semiconductor laser element of the present invention.

[0027]

The base member 1 of the package is made of a ceramic material such as an aluminum oxide sintered compact, an aluminum nitride sintered compact, a mullite sintered compact, a silicon carbide sintered compact, a silicon nitride sintered compact, glass ceramics, or the like, or a metal such as a tungsten porous material impregnated with copper, an iron-nickel alloy, an iron-nickel-cobalt alloy, or the like. The base member 1 is mainly composed of a substantially flat base plate part 1a and a frame-like sidewall part 1b. The base plate part 1a and the sidewall part 1b may be formed of the same material or may be formed of different materials. When the base plate part 1a and the sidewall part 1b are formed of different materials, however, it is preferable to select a combination of materials the difference between thermal expansion coefficients of which is as small as possible.

[0028]

The Peltier element 3 is mounted on and fixed to the upper face of the base plate part 1a of the base member 1. The Peltier element 3 functions as a heat pump for cooling or heating the semiconductor laser element 4 to a predetermined temperature. The Peltier element 3 cools or heats the semiconductor laser element 4 based on the information as to the temperature of the semiconductor laser element 4 measured by the temperature measuring element 5 such that the semiconductor laser element 4 has a predetermined temperature.

[0029]

The subcarrier 6 for mounting a semiconductor laser element is mounted on and fixed to the upper face of the Peltier element 3. On the subcarrier 6 are disposed the semiconductor laser element 4 and the temperature measuring element 5.

[0030]

As illustrated in the perspective view shown in FIG. 2, the subcarrier 6 includes a mount part 8 for mounting the semiconductor laser element 4 and the temperature measuring element 5 for measuring the temperature of the semiconductor laser element 4 that are disposed on the upper face of a rectangular flat substrate 7 made of an electrical insulating material such as an aluminum oxide sintered compact, quartz, an aluminum nitride sintered compact, a silicon carbide sintered compact, a silicon nitride sintered compact, glass ceramics, silicon, or the like. In addition, a joint metallic layer (not shown in the figure) for joining the subcarrier 6 to the Peltier element 3 is adhered to the lower face of the substrate 7.

[0031]

When being made of, for example, an aluminum oxide sintered compact, the substrate 7 can be fabricated as follows: base powder is prepared through the addition and mix of suitable organic binder and solvent to ceramic powder of aluminum oxide, silicon oxide, magnesium oxide, calcium oxide, or the like, subsequently a predetermined die is filled with this base powder to form a green ceramic compact, and this green ceramic compact is calcined at a temperature of about 1600°C. Alternatively, the substrate 7 can be fabricated as follows: slurry is prepared through the addition and mix of suitable organic binder and solvent to ceramic powder of aluminum oxide, silicon oxide, magnesium oxide, calcium oxide, or the like, subsequently the slurry is formed into a sheet shape by using a conventionally known doctor blade method, and this sheet is cut to have a suitable size and then is calcined at a temperature of about 1600°C.

[0032]

Note that in the case where the substrate 7 is made of an

aluminum nitride sintered compact, a silicon carbide sintered compact, a silicon nitride sintered compact, or silicon, since such a material has a high thermal conductivity, namely at least 40 W/m·K, heat can be transmitted excellently between the Peltier element 3 and the semiconductor laser element 4 mounted on the subcarrier 6 and thereby the temperature of the semiconductor laser element 4 can be controlled quickly.

[0033]

The mount part 8 disposed on the upper face of the substrate 7 functions as a base metal for fixing the semiconductor laser element 4 to the substrate 7. To the upper face of the mount part 8 is attached the semiconductor laser element 4 with a low melting point brazing filler metal such as a gold-tin alloy or the like.

[0034]

The mount part 8 is formed of, for example, a metal thin film with a three-layer structure including a titanium film, a platinum film, a gold film sequentially from the side of the substrate 7. The titanium film serves as an adhesion metal with respect to the substrate 7 and has a thickness of about 100 to 2000 angstroms. The platinum film serves as a barrier layer for preventing titanium contained in the titanium film from diffusing into the gold film and has a thickness of about 500 to 10000 angstroms. The gold film serves for improving the wettability with respect to the brazing filler metal that is required when the semiconductor laser element 2 is attached to the mount part 5. The gold film has a thickness of about 1000 to 50000 angstroms.

[0035]

The titanium film, the platinum film, the gold film composing such a mount part 8 are formed as follows: these metal films are allowed to adhere to the upper face of the substrate 7 by using a conventionally known thin film formation technique such as sputtering technique, ion plating, a deposition method, or the like, and are etched into a predetermined pattern by using conventionally known photolithographic technique.

[0036]

The temperature measuring element 5 also disposed on the upper face of the substrate 7 is a resistance temperature sensor for measuring the temperature of the semiconductor laser element 4. The temperature measuring element 5 is made of a resistance material with a temperature coefficient of resistance (TCR) of at least 1000 ppm/°C such as molybdenum silicide nitride, tungsten silicide nitride, platinum, or the like.

[0037]

When being made of, for example, molybdenum silicide

nitride, the temperature measuring element 5 is formed as follows: molybdenum silicide is sputtered with respect to the surface of the substrate 7 in a nitrogen atmosphere, thereby a molybdenum silicide nitride layer is allowed to adhere thereto, and this molybdenum silicon nitride layer is etched into a predetermined pattern by using the conventionally known photolithographic technique.

[0038]

In the subcarrier 6 of the present invention, the temperature measuring element 5 is disposed so as to surround the mount part 8.

[0039]

The temperature measuring element 5 is formed so as to surround the substantially whole periphery of the mount part 8 with a substantially constant interval of 0.01 to 5 mm provided between the temperature measuring element 5 and the mount part 8. This allows the temperature measuring element 5 to receive the heat substantially uniformly from the directions corresponding to the entire periphery of the semiconductor laser element 4 with a short distance and thereby the temperature can be measured quickly and highly accurately.

[0040]

Since the temperature measuring element 5 simply is disposed so as to surround the substantially entire periphery of the mount part 8 with a substantially constant interval of 0.01 to 5 mm provided between the temperature measuring element 5 and the mount part 8, the temperature measuring element 5 occupies a smaller area on the substrate 7 as compared to the conventional case of forming a temperature measuring element being bent in a zigzag pattern. As a result, the subcarrier 6 can be miniaturized. At the same time, the Peltier element 3 on which the subcarrier 6 is mounted and the package also can be miniaturized accordingly. Thus, the semiconductor laser module can be miniaturized.

[0041]

When the interval between the temperature measuring element 5 and the mount part 8 is reduced to 0.01 mm or less, there arises a risk of causing electrical short-circuit therebetween. On the other hand, when the interval exceeds 5 mm, the distance from the semiconductor laser element 4 mounted on the mount part 8 to the temperature measuring element 5 increases. This results in poor followingness with respect to the change of temperature of the semiconductor laser element 4. In addition, a larger region is required for providing the temperature measuring element 5 and thereby the size of the substrate 7 tends to increase. Hence, preferably, the interval between the temperature measuring element 5 and

the mount part 8 is in the range of 0.01 to 5 mm.

[0042]

The temperature measuring element 5 has a thickness of 50 to 10000 angstroms. When the temperature measuring element 5 has a thickness below 50 angstroms, the possibility of causing a break in the temperature measuring element 5 increases. On the other hand, when having a thickness above 10000 angstroms, the temperature measuring element 5 has an excessively low electrical resistivity and thus has low sensitivity as a resistance temperature sensor.

[0043]

Terminals 9 to be electrically connected to an external control circuit are connected to both end portions of the temperature measuring element 5.

[0044]

The terminals 9 are formed of, for example, a metal thin film with the same structure as that of the metal thin film forming the mount part 8, which is adhered to the upper face of the substrate 7, so as to cover both the end portions of the temperature measuring element 5. Such terminals 9 may be formed at the same time the mount part 8 is formed, for example, as follows: a resistance material serving as the temperature measuring element 5 is allowed to adhere to the upper face of the substrate 7 and then is etched to form the temperature measuring element 5 having a predetermined pattern, subsequently a metal film serving as the mount part 8 and the terminals 9 is allowed to adhere thereto to cover it, and this metal film is etched so that its portions serving as the mount part 8 and the terminals 9 remain.

[0045]

The joint metallic layer allowed to adhere to the lower face of the substrate 7 is formed of a metal thin film with the same structure as that of the metal thin film forming the mount part 8.

[0046]

On the other hand, a pipe 10 made of a metal such as an iron-nickel alloy, an iron-nickel-cobalt alloy, or the like is attached and fixed to the sidewall 1b of the base member 1 to pass through it.

[0047]

The pipe 10 serves for fixing an optical fiber 11 to the package and the optical fiber 11 is passed through and fixed to the interior of the pipe 10.

[0048]

The optical fiber 11 is disposed such that its end faces the semiconductor laser element 4 and thereby light emitted from the semiconductor laser element 4 can be transmitted to the outside through the optical fiber 11.

[0049]

Furthermore, in the base plate part 1a or the sidewall part 1b of the base member 1, lead terminals 12 made of a metal such as an iron-nickel alloy, an iron-nickel-cobalt alloy, or the like are provided to project to the outside of the package.

[0050]

The lead terminals 12 are disposed so as to pass through the base plate part 1a or the sidewall part 1b of the base member 1 or are connected to wiring electric conductors leading from the inside to the outside of the base member 1, and thereby the interior and the outside of the package can be electrically connected to each other. In addition, to the lead terminals 12 are electrically connected the Peltier element 3, the semiconductor laser element 4, and the temperature measuring element 5 that are disposed inside the package.

[0051]

On the other hand, the cover 2 is a substantially flat plate made of a metal such as an iron-nickel alloy, an iron-nickel-cobalt alloy, or the like. The cover 2 is joined to the upper face of the sidewall part 1b of the base member 1 by, for example, seam welding. Thus, the package composed of the base member 1 and the cover 2 containing the Peltier element 3, the semiconductor laser element 4, the temperature measuring element 5, and the like thereinside is sealed hermetically. When the cover 2 is joined to the sidewall part 1b by seam welding and the sidewall part 1b is formed of a ceramic material or a tungsten porous material impregnated with copper, it is necessary to pre-attach a metallic frame member made of an iron-nickel alloy or an iron-nickel-cobalt alloy to the upper face of the sidewall part 1b as a base metallic member for the seam welding.

[0052]

Hence, according to the subcarrier for mounting a semiconductor laser element and the semiconductor laser module of the present invention, temperature can be measured quickly and highly accurately and a small subcarrier and a small semiconductor laser module can be provided.

[0053]

It should be noted that the subcarrier for mounting a semiconductor laser element and the semiconductor laser module of the present invention are not limited to the one example of the above-mentioned embodiment and can be modified variously as long as they are in the range that does not allow them to depart from the essential characteristics of the present invention. For instance, in the example of the embodiment described above, titanium was used as an adhesion metal and

platinum for the barrier layer in the metal thin film forming the mount part 8 and the terminal parts 9 of the subcarrier 6. However, chromium, Nichrome, tantalum, or the like may be used as the adhesion metal, and palladium, Nichrome, a titanium-tungsten alloy, or the like may be used for the barrier layer.

[0054]

Furthermore, when platinum is used for the barrier layer of the mount part 8 of the subcarrier 6 and also is used for the temperature measuring element 5; the mount part 8, the terminals 9, and the temperature measuring element 5 may be formed as follows: an adhesion metal film, a platinum film, and a gold film are allowed to adhere sequentially to the upper face of the substrate 7 and then are etched so that all the metal films including the adhesion metal film, the platinum film, and the gold film remain in the regions serving as the mount part 8 and the terminals 9 and only the adhesion metal film and the platinum film remain in the region serving as the temperature measuring element 5.

[0055]

Moreover, a brazing filler metal made of, for example, a gold-tin alloy for attaching the semiconductor laser element 4 may be allowed to adhere to the upper face of the mount part 8 of the subcarrier 6 to have a predetermined thickness by using the sputtering technique or the like. In this case, the time and energy required for placing the brazing filler metal can be saved in mounting the semiconductor laser element 4 on the mount part 8.

[0056]

[Effect of the Invention]

According to the subcarrier for mounting a semiconductor laser of the present invention, the temperature measuring element is disposed so as to surround the mount part where the semiconductor laser element is to be mounted. Hence, the distance from the temperature measuring element to the semiconductor laser element is allowed to be shortened and the temperature measuring element can receive the heat of the semiconductor laser element substantially uniformly. Thus, the temperature can be measured quickly and highly accurately. At the same time, the temperature measuring element does not occupy a large area on the subcarrier and thereby the subcarrier can be miniaturized.

[0057]

Moreover, according to the semiconductor laser module of the present invention including the above-mentioned subcarrier, the temperature measuring element provided on the subcarrier can measure the temperature of the semiconductor laser element accurately with high followingness and based on the temperature information thus obtained, the Peltier element

can be operated quickly and highly accurately. Hence, the temperature of the semiconductor laser element located inside the package can be kept at a constant temperature continually and thereby light with a predetermined wavelength can be emitted stably from the semiconductor laser element. In addition, since a small subcarrier is contained, accordingly the Peltier element on which the subcarrier is mounted and the package also are not required to have large sizes. Thus, a small module can be provided.

[Brief Description of the Drawings]

[FIG. 1] FIG. 1 is a cross-sectional view showing an example according to an embodiment of a semiconductor laser module of the present invention.

[FIG. 2] FIG. 2 is a perspective view showing a subcarrier for mounting a semiconductor laser element of the present invention used in the semiconductor laser module shown in FIG. 1.

[FIG. 3] FIG. 3 is a cross-sectional view showing an example of a conventional semiconductor laser module.

[FIG. 4] FIG. 4 is a perspective view showing a subcarrier for mounting a semiconductor laser element used in the semiconductor laser module shown in FIG. 3.

[Description of Reference Numerals]

1······base member
2······cover
3······Peltier element
4······semiconductor laser element
5······temperature measuring element
6······subcarrier
7······substrate
8······mount part

FIG. 1

3	PELTIER
5	MEASURING ELEMENT
10	PIPE
11	FIBER
12	LEAD TERMINAL

FIG. 2

5	MEASURING ELEMENT
6	SUBCARRIER
8	MOUNT PART
9	TERMINAL

FIG. 3

21	PACKAGE CERAMICS
23	PELTIER
26	SUBCARRIER
28	FIBER

FIG. 4

25	MEASURING ELEMENT
26	SUBCARRIER
30	SUBSTRATE
31	METAL THIN FILM